

**CLAIMS**

What is claimed is:

1. (Currently amended) A machine comprising:  
a sensor or transducer;  
5 a compound phase pattern for use on a reference surface of said machine to compute the cross-track position relative to said pattern, said pattern described in logical coordinates in the time or down-track direction and in the orthogonal or cross-track direction, said pattern comprising a plurality of full servo blocks, and said full servo blocks comprising:
  - a. basic elements in the form of slender parallelograms with detectable transitions at the 10 long edges of said parallelograms, and
  - b. certain of said basic elements called timing elements with said detectable transitions along isochrones or lines of equal values of said time coordinate, and
  - c. one or more special groups of said timing elements to distinguish certain of said servo 15 blocks or to identify a particular location as a timing reference within said servo blocks, and
  - d. a plurality of phase bursts or groups of said basic elements at predetermined angles relative to said isochrones and with various predetermined pitches in said cross-track direction and with the same period  $\lambda$  in said down-track direction and spanning predetermined numbers of cycles in said down-track direction, with combinations of 20 phases of said phase bursts encoded to define a unique cross-track position,

whereby both fine and coarse components of said cross-track position are computed from phase information of data obtained from said transducer scanning said compound phase pattern only once in said down-track direction.

25 ~~whereby the small variation of widths of said basic elements mitigates magnetic transfer of said pattern to said reference surface of a magnetic recording device, and whereby said compound phase pattern can be used as the final servo pattern for said magnetic recording device.~~

30 2. (Previously presented) The machine of claim 1 wherein two of said phase bursts, designated burst A having phase  $\Phi_A$  and burst B having phase  $\Phi_B$  with said  $\Phi_A$  and said  $\Phi_B$  normalized to the standard interval of values greater or equal zero and less than  $2\pi$ , comprise said basic elements with the same cross-track pitch and with slopes of the same magnitude

but of opposite sign in said logical coordinates, and wherein the fundamental phase difference  
35 or  $\Phi_0$  is computed from:

if  $\Phi_A \geq \Phi_B$  then  $\Phi_0 = \Phi_A - \Phi_B$  else  $\Phi_0 = \Phi_A - \Phi_B + 2\pi$  ,

whereby said  $\Phi_0$  varies with said cross-track coordinate at twice the rate of  $\Phi_A$  or  $\Phi_B$ .

3. (Previously presented) The machine of claim 2 wherein said phase bursts other than said  
40 burst A or said burst B form an ordered sequence called higher order bursts, and each of said  
higher order bursts has said cross-track pitch equal to a predetermined burst-specific integer  
multiplier times said cross-track pitch of said  $\Phi_0$  , and  
wherein a predetermined burst-specific constant or basic offset is added to the measured  
phase of each of said higher order bursts and the result is normalized to form its adjusted  
45 phase or principal value in said standard interval and with each of said principal values of  
said higher order bursts having value zero at the same cross-track location as a particular zero  
of said  $\Phi_0$ .

4. (Previously presented) The machine of claim 3 wherein said burst-specific integer  
50 multipliers of said higher order bursts are relatively prime, and said adjusted phase of each of  
said higher order bursts determines a unique segment index equal to the integer part of the  
product of said adjusted phase and said burst-specific integer multiplier divided by  $2\pi$ , and  
the unique cycle number of said  $\Phi_0$  is computed from a predetermined algorithm based on  
said segment indices obtained for each of said higher order bursts, and said cross-track  
55 position coordinate is computed as the sum of said unique cycle number plus the fraction  
given by said  $\Phi_0$  divided by  $2\pi$  ,

whereby said cross-track position is unique over the number of cycles equal to the product of  
60 said relatively prime integers describing said cross-track pitches of said higher order  
bursts, and

whereby said cross-track position can be scaled to any convenient range.

5. (Previously presented) The machine of claim 3 wherein said cross-track pitch of the first  
65 of said ordered sequence of said higher order bursts equals a first integer or burst-specific  
radix times said cross-track pitch of said  $\Phi_0$  and said cross-track pitch of all other of said

higher order bursts equals a burst-specific radix times said cross-track pitch of the preceding member of said ordered sequence of said higher order bursts,

whereby the integer part of the product of said adjusted phase of said higher order burst and  
70 said burst-specific radix divided by  $2\pi$  forms the segment index for said higher order burst, and

whereby said segment indices are combined with said radices in a positional number system to identify a unique cycle number of said  $\Phi_0$ , and

whereby the cross-track position coordinate is computed as said unique cycle number plus  
75 said  $\Phi_0$  divided by  $2\pi$ , and

whereby said cross-track position can be scaled to any convenient range.

6. (Previously presented) The machine of claim 5 wherein said servo pattern further comprises a plurality of short servo blocks that contain only a plurality of said phase bursts,

80 whereby the sample windows for said phase bursts of said short servo blocks are determined by time delays measured from a preceding one of said servo blocks, and other values of said phase information are taken from a preceding one of said servo blocks, and whereby more of the reference surface is available for other uses.

85 7. (Currently amended) A system for computing the absolute cross-track position of a read-write transducer of a magnetic recording device comprising:

- a. A compound phase pattern on a recording surface of said device defined by basic elements or slender parallelogram shaped regions with magnetization opposite the background state, said basic elements described in logical coordinates in the time or down-track direction and in the perpendicular or cross-track direction comprising:
  - (i) timing elements or certain of said basic elements with long edges or transitions along isochrones or lines of equal values of said time coordinate, and
  - (ii) an ordered sequence of phase bursts comprising certain of said basic elements with long edges at predetermined angles relative to said timing elements, with the same predetermined pitch in the down-track direction, and with various burst-specific cross-track pitches;

100        b. a first means to scan said pattern with said read-write transducer during relative motion in said down-track direction;

100        c. a second means to compute phase information from the signal generated by said transducer as it scans said phase bursts in said down-track direction;

100        d. a third means to combine said phase information from said phase bursts to compute a unique cross-track position defined over a range determined by said pitches of said phase bursts;

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whereby said absolute cross-track position is computed from said phase information of a single scan of local data of said pattern, and

whereby the small variation of line widths mitigates magnetic transfer of said pattern to said recording surface.

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~~whereby contemporary read-write channels can be used to analyze said phase information in said magnetic recording device.~~

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8. (Previously presented) The system of claim 7 wherein two of said phase bursts designated burst A and burst B comprise said basic elements with the same cross-track pitch and with slopes of the same magnitude but opposite signs in logical coordinates and said first means and said second means yield corresponding phase values  $\Phi_A$  and  $\Phi_B$  with said phase values in the standard interval  $0 \leq \Phi < 2\pi$ , and said third means combines said phase values to form the fundamental phase difference or  $\Phi_0$  according to:

if  $\Phi_A \geq \Phi_B$  then  $\Phi_0 = \Phi_A - \Phi_B$  else  $\Phi_0 = \Phi_A - \Phi_B + 2\pi$  ,

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whereby said  $\Phi_0$  varies in said cross-track direction at twice the rate of  $\Phi_A$ .

9. (Previously presented) The system of claim 8 wherein said cross-track pitches of said phase bursts other than said A and said B bursts are all integer multiples of half the pitch of said A or said B burst.

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10. (Currently amended) The system of claim 9 wherein said second means to compute phase information adds a burst-specific constant offset to the measured value of said phase of each of said higher order bursts and then normalizes the result to form its adjusted value in said standard interval so that said adjusted values of all of said higher order adjusted phases have a zero located at a particular zero of said  $\Phi_0$ .

11. (Currently amended) The system of claim 10 wherein ratios of said cross-track pitches of said higher order bursts are all relatively prime integers times the cross-track pitch of said  $\Phi_0$ , and said third means forms for each of said higher order bursts the product of said relatively prime integer with the ratio of said adjusted phase divided by  $2\pi$ , and the integer part of said product forms the segment index of said higher order burst, and said third means computes the unique cycle number of said  $\Phi_0$  from a predetermined algorithm based on said segment ~~indices~~ indices, and said cross-track position coordinate is computed as the sum of said cycle number plus the fraction of a cycle given by said  $\Phi_0$  divided by  $2\pi$ ,

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whereby said cross-track position coordinate can be scaled to any convenient range.

12. (Previously presented) The system of claim 10 wherein the ratio of said cross-track pitch of the first of said ordered sequence of higher order bursts is an integral multiple or first burst-specific radix times said cross-track pitch of  $\Phi_0$ , and said cross-track pitch of successive members of said ordered sequence of higher order bursts is a burst-specific radix times said cross-track pitch of the preceding of said higher order bursts, and said third means forms the product of said burst-specific radix with the ratio of said adjusted phase over  $2\pi$ , and the integer part of said product forms the segment index of said higher order burst, and said third means computes the unique cycle number of said  $\Phi_0$  as a positional number based upon said segment indices and said radices, and said cross-track position coordinate is computed as the sum of said cycle number plus the fraction given by said  $\Phi_0$  divided by  $2\pi$ ,

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whereby said cross-track position coordinate can be scaled to any convenient range.

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13. (Previously presented) A method of computing a cross-track position coordinate for a system comprising steps:

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- a. providing a compound phase pattern defined in logical down-track and cross-track coordinates on a scannable surface of said system, said pattern comprising extended servo blocks comprising strips or regions in the form of slender parallelograms with detectable edges wherein:
  - (i) certain collections of said strips called timing elements have said detectable edges at constant values of said down-track coordinate and certain of said timing

elements provide a timing reference and other groups of said timing elements  
165 identify said extended servo blocks or identify a certain position within said  
extended servo blocks, and  
(ii) a plurality of phase bursts each comprising phase elements or certain of said  
strips spaced with the same period  $\lambda$  in said down-track direction and with said  
phase elements of each of said phase bursts at the same predetermined angle  
170 relative to said timing elements, said predetermined angle being unique for each  
of said phase bursts;

b. providing transducer means to scan said compound phase pattern at essentially  
constant relative speed in said down-track direction to produce a read signal from said  
detectable edges;

175 c. providing signal processing means to measure the raw phases of portions of said read  
signal from each of said phase bursts and to select the principal value in the standard  
interval starting at 0 and including all positive values less than  $2\pi$ ;

d. providing computation means to combine said phases and determine said cross-track  
position;

180 e. executing a self-test procedure to measure actual characteristics including minor  
alignment errors and eccentricity of said compound phase pattern;

f. recording results of said self-test procedure in a memory component of said system  
for use in later operation;

185 g. operating said system with steps comprising:  
(i) retrieving said results of said self-test procedure from said memory component  
(ii) scanning said compound phase pattern with said transducer means to produce  
said read signal  
(iii) using said signal processing means to measure said phases of said phase bursts  
(iv) applying said computation means to combine said phases and said results of  
190 said calibration procedure to determine said cross-track position

14. (Previously presented) The method of claim 13 wherein

a. two of said phase bursts, designated burst A and burst B, have said phase elements  
with slopes of the same magnitude but of opposite sign in said logical coordinates,  
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200 b. all other of said phase bursts form an ordered sequence of higher order bursts wherein the first higher order burst of said ordered sequence has said cross-track period that is an integer multiple or first radix times half of said cross-track period of burst A or burst B and wherein said cross-track period of other members of said ordered sequence of higher order bursts is equal to a burst-specific radix times the cross-track period of the preceding member of said ordered sequence of higher order bursts.

15. (Previously presented) The method of claim 14 wherein during said operating step:

a. the raw phase of each of said phase bursts is measured, and

205 b. said results of said self-test procedure are used

(i) to add a standard offset to said raw phase of said B burst so that, on average,

$\Phi_B = \Phi_A$  at values of said cross-track coordinate where  $\Phi_A = \pi/2$ , and

(ii) to add a burst-specific offset to said raw phases of all said higher order phase bursts so the resulting phases have, on average, a zero at a particular cross-track 210 location where  $\Phi_B = \Phi_A$ , and

(iii) to compute the fundamental phase difference or  $\Phi_0$  as

**if  $\Phi_A \geq \Phi_B$  then  $\Phi_0 = \Phi_A - \Phi_B$  else  $\Phi_0 = \Phi_A - \Phi_B + 2\pi$  ;**

c. the resulting phase value of the first of said ordered sequence of higher order phase bursts is adjusted by adding  $(\pi - \Phi_0) / (\text{said first radix})$ , and by adjusting said resulting phase of other members of said ordered sequence of higher order bursts by adding  $(\pi - \text{said adjusted phase of the preceding higher order burst}) / (\text{said burst-specific radix})$  to urge said resulting phase value to the middle of the appropriate phase segment, and normalizing said adjusted phase to the principal value in said standard interval, and

215 220 d. forming the result of multiplying said normalized phase value by said burst-specific radix and dividing by  $2\pi$  then selecting the integer part of said result as the segment index for said phase burst, and

e. combining said segment indices and said first radix and said burst-specific radices in a 225 positional number system to provide the unique cycle index of said  $\Phi_0$  as the integer part and adding the fraction of said  $\Phi_0$  divided by  $2\pi$  to form said cross-track position coordinate.

16. (Previously presented) The method of claim 15 wherein small values of clock error  $\tau$  are computed from:

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$$\delta = (\Phi_A + \Phi_B) / 2$$

**if  $\delta \geq \pi$  then  $\tau = \delta - 3\pi / 2$  else  $\tau = \delta - \pi / 2$**  ,

and said clock error  $\tau$  is subtracted from said resulting phase value of step (15. b.) before normalizing

235 17. (Previously presented) The method of claim 15 wherein said predetermined angle of said phase elements of one of said higher order bursts is zero, and said clock error  $\tau$  is computed as the variation of said phase from its average value, and said clock error  $\tau$  is subtracted from said resulting phase of step (15. b.) before normalizing.

240 18. (Previously presented) The method of claim 15 wherein said pattern further comprises short servo blocks, said short servo blocks containing only certain of said position phase bursts, and wherein sampling windows for reading said signal from said phase bursts of said short servo blocks are determined by timing delays measured from a previous servo block,

245 whereby additional area of said scannable surface of said system is made available for other uses.

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